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THE ACTIVITIES OF HOUSE FLIES¹

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INTRODUCTION

The observations that are described herein were undertaken to obtain a better understanding of the activities of house flies. It was desired to keep a given fly under continuous observation for periods of several hours at a time. Since it was impossible to make such observations using free flies out-of-doors, it was necessary to confine them in a cage small enough to enable the constant, desired observations to be made.

DESCRIPTION OF PROCEDURE

Pairs of flies of known age and of normal size were confined in a cage, each inside dimension of which was 12 inches, or which was of one cubic foot capacity. The cage was constructed so that it could be taken apart quickly to facilitate cleaning. The two sides, the bottom and the back were of unpainted plywood; the top was of wire screening of 16 mesh, and the front was of glass. When in use the cage was placed on a table about four feet below a light consisting of two GE Mazda Daylight Fluorescent

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bulbs. The temperature was about 75° F. Two workers cooperated, one who watched a fly continuously, using a stop-watch to time the various activities observed, and dictated the observations to a second worker who entered the information on prepared forms. The activity of one fly of a pair was observed and recorded in this way for continuous periods ranging from 30 minutes to three hours. Information applicable to 22 females and 16 males was obtained and will be described in the following sections.

AGE OF FLIES AND LENGTH OF TIME OBSERVED

The flies of each sex, that were observed, ranged in age from newly emerged individuals to those that had emerged 11 days before. Although each observation was scheduled for a particular length of time, it was never possible to account for exactly the planned interval because short periods were unavoidably gained or lost at each change of activity of a fly which, during the course of one experiment, might result in several hundred separate observations to be entered on the data sheets. A compilation of the data applicable to each fly gave the exact time for which observations were obtained, and these totals served as a basis for the calculations given herein.

TIME SPENT IN SIX CATEGORIES OF ACTIVITY

Prior observations of flies under the conditions of the experiments showed that their activity could be divided into six categories. They spent much time in resting; intermittently they cleaned their feet, head, mouth parts, wings or abdomen; they sought food with the proboscis extended; they fed; they regurgitated the food—which evidently is a part of digestion, and they walked or flew about without reference to food-seeking and, in the males, this often consisted of advances to the female. Therefore all the activities of the flies were classified under the following categories:—1, walking or flying; 2, searching for food; 3, feeding; 4, regurgitating; 5, resting; and 6, cleaning. A summary showing the percentages of time observed that was spent by each fly in each of these activities is given in table 1.

TABLE 1
COMPARISON OF THE TIME SPENT BY HOUSE FLIES IN EACH OF SIX
CATEGORIES INTO WHICH THEIR ACTIVITY WAS DIVIDED

Age in days	Time spent by individual flies in the following activities					
	Walking or flying	Searching for food	Feeding	Regurgitating	Resting	Cleaning
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
<i>FEMALES</i>						
0	0.1	.....	.....	.....	68.2	31.7
0	2.8	10.6	20.1	51.2	5.2	10.1
0	1.1	.....	.....	.....	82.4	16.5
1	2.3	10.0	4.4	76.1	.....	7.2
1	1.0	7.7	5.9	45.1	12.5	27.8
1	0.2	0.8	.....	.....	90.5	8.5
1	0.8	27.9	3.2	19.5	6.3	42.3
1	3.7	7.3	2.0	78.1	0.7	8.2
1	.....	.....	.....	.....	94.1	5.9
2	1.7	1.7	2.2	.....	89.6	4.8
3	6.0	1.3	.....	4.9	74.3	13.5
3	2.6	1.3	1.4	23.3	57.2	14.2
4	5.0	7.4	1.2	66.9	8.3	11.2
5	1.6	.....	.....	.....	83.7	14.7
6	0.4	37.1	3.2	35.0	6.9	17.4
6	4.6	36.4	.....	.....	43.6	15.4
7	10.4	14.7	.....	.....	63.3	11.6
9	15.3	0.2	2.8	34.0	26.1	21.5
11	4.8	5.0	3.1	57.6	13.5	16.0
11	4.4	3.0	.....	54.0	29.0	9.6
?	29.9	.....	.....	10.9	40.9	18.3
Average	4.3	8.4	2.5	29.7	40.6	14.5
<i>MALES</i>						
0	2.7	3.2	1.5	30.8	38.1	23.7
0	.....	5.4	.....	.....	83.0	11.6
2	1.0	11.0	14.0	56.4	4.1	13.5
2	6.7	0.5	6.5	60.9	11.5	13.9
2	1.2	20.3	10.9	49.6	5.8	12.2
2	4.8	36.5	2.5	.....	36.7	19.5
2	0.2	15.8	2.8	56.6	0.2	24.4
2	1.8	1.0	.....	.....	88.6	8.6
3	43.3	5.2	3.2	11.2	10.7	26.3
4	45.9	0.5	.....	.....	2.7	50.9
5	14.9	7.7	5.4	21.8	23.3	26.9
7	53.8	3.5	0.3	.....	30.3	12.1
8	37.5	4.2	1.0	12.4	20.1	24.8
10	26.0	0.9	4.1	.....	27.6	41.4
10	5.8	0.2	9.9	59.1	5.7	19.3
11	8.7	.....	0.1	.....	64.6	26.6
Average	16.2	8.1	4.1	23.0	27.9	20.7

CHOICE OF RESTING PLACES

In the cage that has been described there was a choice of three types of surfaces on which the flies could rest, including resting during regurgitation. Observations showed that they preferred to rest on the plywood and wire screening, but avoided the glass. When cleaning the middle legs were used less often than the others, and one middle leg rested on the surface at all times. The tarsi of these legs were observed to slip on the vertical glass surface indicating that it did not afford a secure foothold for the flies and that they avoided it for this reason.

The avoidance of glass surfaces has been shown also by the choice of resting places by flies in small rectangular cages in which the sides, bottom and top were of glass, and the two ends were of cloth. In these cages the flies carried on most of their activities on the cloth, leaving it only to search for food or when they were disturbed. In these cages this choice by the flies was shown by the occurrence of excrement specks, which were found much more abundantly on the cloth than on the glass. It was indicated, therefore, that the relative smoothness of surfaces was a factor in the choice of resting places by the flies and that they avoided very smooth surfaces on which their foothold was insecure.

FINDING OF FOOD AND THE DURATION OF FEEDING

In these experiments the food provided for paired flies consisted of milk on cotton in 10 cc. beakers placed in the center of the bottom of a cage. The observations failed to show that the flies were attracted to this food by odor. They seemed to find it rather accidentally after searching for a shorter or longer period. The length of time that previously unfed flies searched before finding the food was, for 8 males from 8 seconds to 46 minutes, 37 seconds; and for 7 females from 2 minutes, 28 seconds to 139 minutes, 15 seconds. The average searching time for the males was 11 minutes, 14 seconds, and it was 31 minutes, 44 seconds for the females. After the food was found the males fed for periods ranging from 66 seconds to 3 minutes, 10 seconds, or an average of 1 minute, 39 seconds, and the females fed for periods ranging

from 40 seconds to 6 minutes, 55 seconds, or an average of 2 minutes, 15 seconds.

REGURGITATION

Heretofore it has been known that house flies regurgitated food, but the details of the regurgitation and the probable reason for this activity has been little understood. Regurgitation began soon after feeding and continued for some time, probably depending on the amount of food that had been taken. When milk was colored with red stain the regurgitated droplets at first were colored identical with the colored milk, but as the process continued the color gradually became less intense until the droplets were colorless. It was indicated, therefore, that regurgitation is a process of digestion during which the food is brought up from the crop bit by bit and is mixed with saliva before being passed on to the digestive tract. Of the 679 regurgitated droplets observed only one was dropped, indicating that fly specks consist almost entirely of excrement.

The duration in time of individual exposed droplets at the end of the proboscis varied from less than 15 seconds to more than 3 minutes for both males and females, as shown in table 2. The average duration of droplets by male flies was 73.3 seconds and for female flies it was 76.5 seconds. The total number of droplets regurgitated by individual flies, which were observed for varying lengths of time, ranged from 6 to 53, or an average of 32 for the males and from 1 to 76, or an average of 32.6, for the females.

The length of time droplets were exposed ranged from 33.3 to 139.7 seconds for the females and from 34.3 to 188.8 seconds for the males. For male flies 61.1 per cent of the droplets were exposed for one minute or less, 21.2 per cent for from 1 to 2 minutes, 10.8 per cent for from 2 to 3 minutes, and 6.9 per cent for more than 3 minutes. For female flies 56 per cent of the droplets were exposed for one minute or less, 25.6 per cent for from 1 to 2 minutes, 10.5 per cent for from 2 to 3 minutes, and 7.9 per cent for more than 3 minutes.

In the case of female flies the duration of regurgitated droplets of flies one day old was much greater than was the case with older

TABLE 2
 COMPARISON OF THE LENGTH OF EXPOSURE IN SECONDS OF DROPLETS REGURGITATED BY HOUSE FLIES

Sex	Percentage of droplets that were exposed for the following periods in seconds														
	0- 15	16- 30	31- 45	46- 60	61- 75	76- 90	91- 105	106- 120	121- 135	136- 150	151- 165	166- 180	Over 180		
Females	9.7	16.9	19.4	10.0	9.5	7.9	4.9	3.3	2.3	4.1	2.3	1.8	7.9		
Males	12.2	20.1	15.3	13.5	8.0	5.6	4.9	2.8	3.5	4.5	1.7	1.0	6.9		

flies. The average number of droplets regurgitated by female flies one day old was 46.5 and the average length of time they were exposed was 99.2 seconds. For female flies from 3 to 6 days old these figures were 24.5 droplets and 66.6 seconds, and for female flies from 9 to 11 days old they were 21 droplets and 34.9 seconds. Since a similar correlation was not observed in the case of male flies it is probable that the observations noted as being applicable to the females were related to the development of eggs by the young females.

The process of regurgitation was frequently interrupted by movements of the fly or by cleaning without other movement. It occurred after the flies had moved away from the food and were resting in any position on parts of the cage. Male flies regurgitated from 1 to 18 droplets without movement and female flies regurgitated from 1 to 32 droplets without movement. On an average the male flies regurgitated 4.5 droplets without movement and the females regurgitated 5.4 droplets.

CLEANING

Flies of each sex cleaned themselves intermittently, particularly the males, which spent an average of 20.7 per cent of their time in this way whereas the females spent an average of 14.6 per cent of their time in this activity. As in other respects the flies were quite individualistic in their cleaning activities as may be seen from the data given in table 3.

In this table the insect parts involved in cleaning are represented by symbols which are described in the table. The various combinations of symbols show when the flies used the indicated parts in one cleaning operation. A total of 18 of these combinations were represented in the data, and the table shows the percentage of the time devoted to cleaning when each combination of parts was used.

The fore-legs were used with or without the middle legs to clean the head and mouth parts, and the rear legs were used to clean the wings and abdomen. The middle legs were used for cleaning much less than either of the others and in no case was more than one of them removed at a time from the surface on which a fly rested. More time was devoted to cleaning the head

TABLE 3
COMPARISON OF THE TIME SPENT BY HOUSE FLIES IN CLEANING THEIR SEVERAL PARTS

Age in days	Percentages of the time spent in cleaning that was devoted to cleaning the following body parts														Time spent in Un- deter- mined				
	F	FB	FH	FHB	FM	FMH	FMB	FMHB	FMR	M	MR	MRW	MRA	MRAW		R	RA	RW	RWA
	<i>FEMALES</i>																		
0	9.8	5.8	15.6	22.6	0.7	6.9		22.6							1.1	4.0		7.5	31.7
0	15.6	9.3	31.3	2.0	5.6	2.0					18.2				3.0	5.5	7.5		10.1
0	14.3	29.1	37.7	0.8					5.2						2.4		1.8	8.6	16.5
1	15.0	14.5	7.2		10.8	15.4	23.0								6.5			7.6	7.2
1	18.5	4.5	19.7	2.9	3.2	10.5		6.0					10.2		10.4		12.2	1.9	27.8
1	11.6		20.0		19.3	35.5									3.9		9.7		8.5
1	24.3	9.7	0.2	9.8	12.5	12.1	1.4	12.1			3.7			2.8		8.6	4.2		42.3
1	19.1		9.2	5.7	2.7	5.2								4.3		52.4			8.2
1	6.8		39.2	12.0		9.9				3.2				3.0		25.9			5.9
2	22.6		6.5		28.6											42.3			4.8
3	48.2		15.1		6.8											25.9			13.5
3	3.8	14.8	8.9	23.4	1.5					4.0					0.5		27.5		14.2
4	7.1	6.5	7.2	2.3	4.6	1.9	4.0	15.6							7.4	12.5	20.3	1.5	11.2
5	12.1	7.9	1.1	22.9	5.8		12.7	13.9		0.3	1.8				3.3		43.1		14.7
6	10.6	8.5	4.4	5.0	3.8			3.8							24.5		13.3	7.2	17.4
6	26.8		10.0		6.3	21.4	11.8	10.9							7.5		14.8	8.5	15.4
7	10.8	1.7	10.0	10.4	3.0	5.5	4.7								0.8	1.2	25.2	7.6	11.6
9	11.6	2.2	7.1	2.0	4.5	9.4	10.2	12.7		0.9					9.1	2.0	23.1		21.5
11	5.3	4.5	6.4	15.7				11.8	0.7		2.3			9.3	0.7			34.4	16.0
11	2.6		32.7		9.2	14.6		33.0						2.3				22.3	9.6
?	12.2				3.3	3.8								16.3	11.3		40.2		18.3
Average	15.6	6.3	11.5	8.0	5.3	6.6	3.3	8.6	0.1	0.2	0.6	1.2	1.4	0.8	5.6	1.3	18.3	4.3	14.6

TABLE 3 (Continued)

Age in days	Percentages of the time spent in cleaning that was devoted to cleaning the following body parts														Un-determined	Time spent in cleaning								
	F	FB	FH	FHB	FM	FMH	FMB	FMHB	FMR	M	MR	MRW	MRA	MRAW			R	RA	RW	RWA				
0	52.8	3.6	16.5	1.8	7.8										16.6	0.9								23.7
0	21.9		26.5	11.2	16.7										2.3		2.8	8.8						11.6
2	14.9	2.1	11.7	13.9	8.6	8.1	16.8								8.7		3.8	1.8						13.5
2	11.4	16.1	7.6	16.2		14.5	4.1			2.9					9.6		6.6	2.8						13.9
2	17.7	17.9	12.4		11.4	8.2	10.3								19.1		3.0							12.2
2	13.7	16.9	11.1	7.4	2.0	6.5	5.2			1.4	3.2	7.9		2.9	3.1	0.4	10.5	7.8						19.5
2	4.2	5.2	1.3	13.2	7.3		4.7								42.5		15.3	6.3						24.4
2	7.9		30.7			3.4	10.5				4.2				2.5		16.5	24.3						8.6
3	34.9	12.3	14.0	12.2	1.1	4.4	5.4								8.9		6.8							26.3
4	24.0				3.1												6.9							51.0
5	9.9	7.9	8.1	7.1	5.1		3.5			0.9					1.3		40.1							26.9
7	32.6		4.3	4.0	3.7	3.0	4.4			1.0					2.3		35.4	3.2						12.1
8	39.8		10.9		3.4					3.7					6.0		27.7	4.2						24.8
10	9.6	0.8	10.0	3.1	7.9	9.3	13.4								1.5		14.0	11.7						41.4
10	52.8	3.6	16.5	1.8	7.8										16.6	0.9								23.7
11	12.2	9.7	4.8			3.8	26.4				5.7	16.9			1.4		19.1							26.6
Average	20.0	6.5	10.1	6.4	5.1	4.0	4.7	4.7	0.1	0.2	1.1	4.8	0.2	1.0	8.0	0.1	17.1	4.3						20.7

MALES

The symbols are:

H—head

B—mouth parts

A—abdomen

F—front legs

M—middle legs

R—rear legs

W—wings

and proboscis and fore legs than other parts, as shown in the following summary:

COMPARISON OF THE AVERAGE TIME SPENT BY HOUSE FLIES IN
CLEANING PARTS OF THEIR BODIES

Parts cleaned	Percentage of time devoted to cleaning that involved the use of the stated parts	
	Males	Females
Fore legs, head and mouth parts	42.97	41.30
Fore and middle legs, head and mouth parts	18.56	23.86
Involving the middle and rear legs	7.42	5.28
Rear legs, wings and abdomen	29.50	29.55
Undetermined parts	1.53	

Cleaning involving the use of the fore legs, the mouth parts and head and the rear legs, wings and abdomen accounted for 91 per cent of the time devoted to cleaning by the males and 94.7 per cent by females. The time devoted to cleaning by male flies ranged from 8.6 to 50.9 per cent of the time they were observed, and for female flies this range was from 4.8 to 42.3 per cent.

ADVANCES BY THE MALES

The males were much more excitable than the females, as was indicated by their much greater activity in walking and flying, and after the first few days following emergence they made frequent advances to the females, but they were usually rejected. The data show that the males did not become interested in the females until the second or third day after emergence. Their interest became less from the 4th to the 6th day after emergence, but it increased on the 7th to the 11th day.

During the course of the observations mating was seen in the case of one pair of flies. A female that was one day old was observed in copulation at 8:30 A.M. on July 18, and mating continued until about 9:50, thus lasting for about one hour, 20 minutes.

DEFENCE

The observations showed that the females were quite capable of resisting the advances by the males, and that any fly was well equipped for competition for food or mates with other flies.

In cages where the mass of food was small in proportion to the number of flies, there were frequent clashes for feeding positions about the food. These engagements were carried out by using one or the other of the middle legs as weapons of defense or offense. The appendage was raised high into the air where it was poised until the encroaching fly was close: then it lashed out. A well-placed blow could break several legs or tear a wing to shreds.

A similar action was observed when a single male and female were confined in a cage. After the female had become gravid she fended off the approaches of the male by using one of her middle legs in a similar way. By the fifth or sixth day the male often was crippled in legs or wings or both. It had been noted often that the males died sooner than the females, and that after a few days they were much battered with frayed wings. It appeared that much of this early mortality might be caused by the females when resisting the rather frequent advances by the males. Less frequently the female disturbed the male while he was feeding or regurgitating, in which case he protected himself by the same method.

SUMMARY

Pairs of house flies were confined in a cage in which milk was provided as food. Each was watched continuously for varying lengths of time; their successive activities were observed and timed by use of a stop watch and the observations were entered on forms.

Their activity was divided into six categories: walking or flying, searching for food, feeding, regurgitating, resting, and cleaning. There was much variation in the proportion of time spent by individual flies in each of these activities. The males spent more time in walking, flying and cleaning, and the females spent more time in resting.

After feeding the flies spent much time in regurgitating the food drop by drop. The first-exposed droplets were colored identical with the food, but the color gradually disappeared and the last exposed droplets were a clear liquid. From the observations it appeared that regurgitation was a process of digestion

wherein the food was brought up from the crop and mixed with saliva before passing on to the intestines.

The fore legs were used with or without the middle legs to clean the head and proboscis, and the rear legs were used to clean the wings and abdomen. The middle legs were used for cleaning much less than either of the others and in no case was more than one of them removed at a time from the surface on which the fly rested. More time was devoted to cleaning the head and mouth parts than any other parts.

ARMY-ANT BEHAVIOR

The American Museum of Natural History has just published the results of Dr. T. C. Schneirla's behavior studies entitled "Army-Ant Life and Behavior Under Dry-Season Conditions, 3 The Course of Reproduction and Colony Behavior" (Bull. Amer. Mus. Nat. Hist., Vol. 94, Article 1, p. 1-82, 1949). The observations on which the study is based extended over a period of four and a half months in the dry season on Barro Colorado Island in the Canal Zone and involved the species *Eciton hamatum* and *Eciton burchelli*. The purpose was to determine if the general activities of army ants are materially affected by seasonal dry conditions. Detailed observations of particular colonies for a period of four months are presented together with records of other colonies for shorter periods of time, the whole being followed by an informative and interesting discussion of the variations in different phases of the behavior pattern of these ants. Dr. Schneirla concludes that the cyclic system of events making up the behavior pattern persists during both the rainy and dry seasons and that such differences as occur during the dry season are secondary and do not materially damage the orderly persistence of the events. Dr. Schneirla's present paper is another in his series of authentic and erudite contributions, dealing with the behavior of army ants, over many years.—H. B. W.